NASA TECH BRIEF
Marshall Space Flight Center

Adhesive for Aluminum Withstands Cryogenic Temperatures

The problem:

The existing adhesives that are used for bonding parts to aluminum alloys at room temperatures are prone to failures at cryogenic temperatures. The reason for such failures has been a large difference in coefficients of contraction between the metal and the adhesive in cryogenic temperature ranges.

The solution:

Tests on a polyurethane adhesive which is mixed to various proportions with milled glass fibers have shown that it can match the thermal characteristics of 2014-T6 aluminum at cryogenic temperatures.

How it's done:

Monostrain specimens were fabricated which consisted of a polyurethane adhesive system, 1% by weight of silane, and different experimental percentage quantities of milled glass (length 1/32 inch or 0.79 mm) fibers. The quantity of milled fibers was varied from 15 to 65% to determine their effect on the physical characteristics of the polyurethane adhesive. Samples were made of the 68.58-cm (27-inch) adhesive composite and were cured at room temperature for at least seven days prior to the tests. The samples were then tested down to 125K (-300°F) for coefficient of contraction ($\Delta L/L$, where L is the length of the sample), the tensile modulus (E), the ultimate tensile strength, and the percentage of elongation at failure.

Results of these tests showed that, with 15% glass fibers, the coefficient of contraction from room temperature to 125K was approximately 0.0072; with 65% glass fibers, however, the contraction was approximately 0.0033. The tensile modulus at 125K varied from 7.38×10^9 to 11.73×10^9 N/m^2 (1.07×10^6 to 1.70×10^6 psi) for 15 and 65% fiber content, respectively. The ultimate tensile stress at 125K varied from 75.90×10^6 to 10.01×10^7 N/m^2 (11000 to 14500 psi) and showed a slight increase toward the 65% fiber content. Percentage of elongation of the samples before the breakage varied from 1.22 to 0.72% with a slight decrease for larger proportion of fiber contents.

Additional tests of the metal-to-metal lap shear strength performed on the polyurethane containing 30, 50, and 65% of glass fibers were conducted at room temperature and 125K. Results revealed that the sample shear strength was 41.4×10^6N/m^2 (6000 psi) throughout at 125K, which exceeded the 27.6×10^6 N/m^2 (4000 psi) requirement.

Shear strengths on all samples at room temperature exceeded the 6.9×10^6 N/m^2 (1000 psi) by 12 to 50%.

Note:

Requests for further information may be directed to:

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Patent status:

No patent action is contemplated by NASA.

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